REMOTE PATIENT MONITORING SYSTEM WITH GARMENT AND AUTOMATED MEDICATION DISPENSER

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Inventor:	SHUSTERMAN LARRY (US)
Applicant:	RAPID PATIENT MONITORING LLC (US); SHUSTERMAN LARRY (US)
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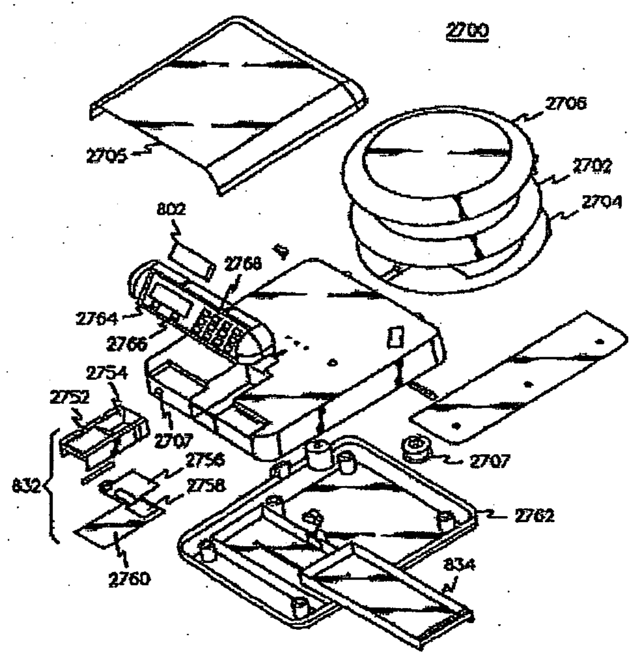
Abstract of **WO0006018**

An integrated remote patient monitoring system (10) including a garment (216), a monitoring device (214) and a medication dispensing unit (212). The garment is adapted for wearing by a patient, and is adapted to house at least one sensor (218) that is in communication with the patient's body. The garment includes a connector (215) communicating with the sensor (218) through the connector(215), and is configured to record signals from the sensor (218). The monitoring device (214) is configured to exchange signals representing patient status with a central station (100). The medication dispensing unit (212) communicates with the monitoring device (214) to receive commands from the monitoring device (214), and to transfer signals representing the status of medication doses to the monitoring device (214).



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(71) Applicant (*for all designated States except US*): RAPID PATIENT MONITORING LLC. [US/US]; 1600 South 28th Street, Philadelphia, PA 19145 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): SHUSTERMAN, Larry [US/US]; 421 Montgomery Avenue, Merion Station, PA 19066 (US).

(74) Agents: LEACE, Benjamin, E. et al.; Ratner & Prestia, 301 One Westlakes (Berwyn), P.O. Box 980, Valley Forge, PA 19482-0980 (US).

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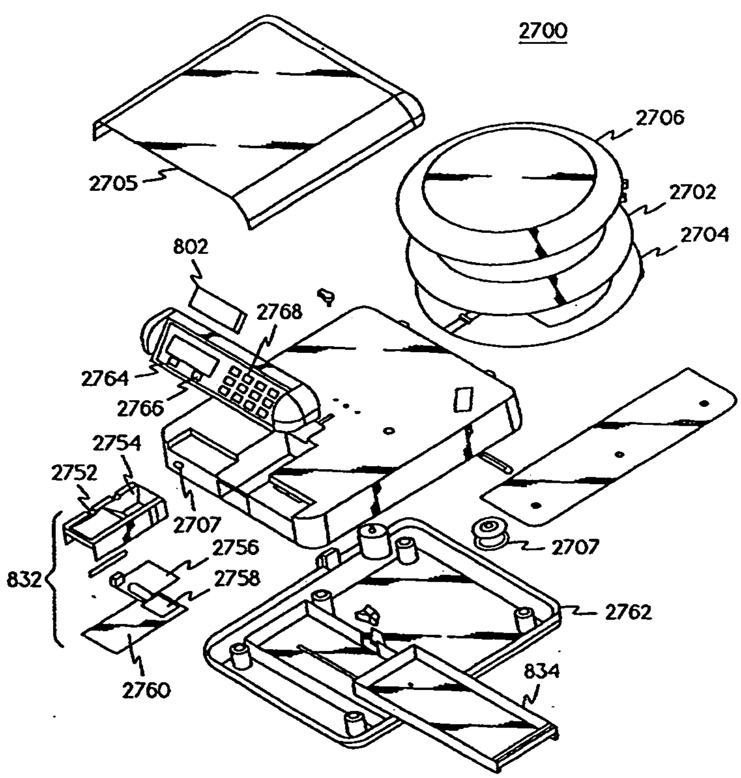
(57) Abstract

A remote patient monitoring system (200) including a garment (216), a monitoring device (214) and a medication dispensing unit (2700). The garment is adapted for wearing by a patient, and is adapted to house at least one sensor (500) that is in communication with the patient's body. The garment includes a connector (215) communicating with the sensor. The monitoring device communicates with the sensor through the connector and is configured to exchange signals representing patient status with a central station (100). The medication dispensing unit (2700) communicates with the monitoring device to receive commands from the monitoring device and to transfer signals representing the status of medication doses to the monitoring device.



REMOTE PATIENT MONITORING SYSTEM WITH GARMENT AND AUTOMATED MEDICATION DISPENSER

This Application is a Continuation In Part of U.S. Non-Provisional Patent Application Serial No. 09/126,662 Filed July 30, 1998.

FIELD OF THE INVENTION

This invention pertains generally to patient monitoring, and more specifically to monitoring patient status and communicating with a patient from a point remote from the patient's location.

BACKGROUND OF THE DISCLOSURE

An ongoing concern in the medical profession is the containment of labor costs, especially the cost of nursing and other patient monitoring personnel. One way to minimize costs is to find ways to allow fewer nurses to monitor larger numbers of patients without jeopardizing patient safety. In addition, hospitals are discharging patients earlier, allowing them to recuperate at home rather than in the hospital. In a typical hospital setting, nurses must periodically check the patients' vital signs, to administer doses of medicine, and to attend to requests or problems reported by patients. Where patients are recuperating at home or in far-flung branches of a large hospital, however, it is especially difficult for nursing personnel to monitor those remote patients in a cost-effective manner.

Another concern in the medical profession is the accurate administration of prescription medication to patients. Typically, prescription medicine is administered at periodic dosing intervals during a day. These dosing intervals are determined by a dosing schedule established by a treating physician. Medical support personnel administer doses of medication by retrieving the prescribed doses from bulk medicine supplies at the hospital pharmacy. This approach is inefficient and error-prone, because the support personnel often split time between administering medication and performing other duties. Further, to the extent that records of medication doses are kept, those records of medication doses are kept manually by the support personnel themselves. If the personnel are hurried, they may not keep accurate records of medication doses. In addition, the medication doses may not be correct because a harried support person failed to fill the prescription properly.

Yet another concern is the precise placement of the various sensors used to sense a patient's vital signs through physical contact with the patient's body. For example, an EKG sensor operates by sensing electrical activity within the body, and must be placed strategically on

the body best to detect this electrical activity. Similarly, other types of sensors must be placed carefully and precisely for optimum sensing effectiveness. In the context of remote patient monitoring, it is desirable to avoid requiring medical support personnel to travel to the patient's location to place and check the various sensors located on a patient's body. Imposing the expense of such travel on medical support personnel could outweigh any benefits realized by having the patient recuperate at a site remote from the hospital.

SUMMARY OF THE INVENTION

The present invention provides an integrated patient monitoring system that includes a garment, a monitoring device, and a medication-dispensing unit. The garment is adapted for wearing by a patient, and is adapted to place at least one sensor in communication with the patient's body. The garment includes a connector communicating with the sensor. The monitoring device communicates with the sensor through the connector, and records signals from the sensor. The monitoring device also exchanges signals representing patient status with a central station. Preferably, the patient monitoring system restricts access to the monitoring device to authorized personnel. The medication-dispensing unit communicates with the monitoring device to receive commands from the monitoring device, and to transfer signals representing the status of medication doses to the monitoring device.

The garment of the invention includes at least one sensor, a torso portion adapted to fit the torso of a patient and defining at least one aperture to house the sensor, a sleeve portion adapted to fit the arm of the patient, and a connector communicating with the sensor. Either the torso portion or the arm portion defines a one channel linking the connector to the sensor. This channel houses a signal transmission conduit that couples the sensor to the connector.

The automated medication dispenser includes a carousel, a housing, a dosing drawer, a recovery drawer, and a microcontroller. The carousel defines a plurality of compartments, with each of the compartments adapted to store a dose of medication. The housing includes a surface adapted to receive the carousel, with the housing defining a receptacle and an access aperture communicating between the receptacle and the surface adapted to receive the carousel. A first one of the compartments is positioned to communicate with the receptacle through the access aperture. The medication dispenser provides means for rotating the carousel to position a second one of the compartments to communicate with the receptacle through the access aperture.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described by non-limiting examples with reference to the attached drawings, in which:

Fig. 1 is a block diagram of the remote patient monitoring system of the present invention;

Fig. 2 is a block diagram of a remote site as shown in Fig. 1;

Fig. 3 is a diagram illustrating the various components of the environmental control system illustrated in Fig. 2;

Fig. 4 is a diagram illustrating how the central station and the remote site are coupled to exchange data;

Fig. 5 is a diagram of the several patient sensors coupled to the garment shown in Fig. 2;

Fig. 6 is a diagram of an exemplary garment in accordance with the present invention;

Fig. 7 is a diagram of several exemplary sensors that comprise the biosensors and the environmental sensors as shown in Fig. 2;

Fig. 8 is a block diagram of the various components of the medication dispensing unit shown in Fig. 2;

Fig. 9 illustrates an exemplary data structure for a dosing schedule illustrated in Fig. 8;

Fig. 10 illustrates an exemplary structure of the data log illustrated in Fig. 8;

Fig. 11 is an elevated perspective view of the medication dispensing unit, shown from the front;

Fig. 12 is a perspective view of the bottom of the medication dispensing unit;

Fig. 13 is an elevated perspective view of medication dispensing unit, with carousel detached;

Fig. 14 is an exploded diagram of the carousel shown inverted;

Fig. 15 is a flow chart illustrating the flow of processing performed by the microcontroller of the medication dispensing unit;

Fig. 16 is a flow chart illustrating the processing performed by the software running on the PC illustrated in Figs. 2 and 4;

Fig. 17 is a diagram of an exemplary database record storing the data collected during the execution of the software illustrated in Fig. 16;

Fig. 18 is a flowchart of the software running aboard the server;

Fig. 19 is a diagram of an exemplary database record maintained by the server;

Fig. 20 is a flowchart of the software executing on the serial interface box;

Fig. 21 is an exemplary side view of the connector as connected to a cradle provide by the patient monitoring unit;

Fig. 22 is an exemplary front view of the cradle shown in Fig. 22, with the connector removed;

Figs. 23 and 24 are top views of alternate embodiments of the cradle shown in Fig. 22;

Fig. 25 is a diagram of an exemplary data structure used with the medication dispensing unit shown in Fig. 2 to support multi-lingual capability;

Fig. 26 is a diagram of an exemplary data structure used in conjunction with the data structure shown in Fig. 25 to enable the medication dispensing unit to provide messages in several different languages.

Fig. 27 is an exploded view of a medication dispensing unit in accordance with the present invention;

Fig 28 is a top view of a dual ring medication cassette;

Fig 29 is a perspective view of a medication cassette cartridge; and

Fig. 30 is a perspective view of a pharmacy unit in accordance with the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Fig. 1 is a block diagram of a remote patient monitoring system 10 constructed in accordance with the present invention. In a minimum configuration, system 10 includes central station 100 and one remote site 200. However, the system 10 can be extended to include any number of remote sites 200, limited only by the computational resources provided by central station 100. Fig. 1 illustrates an exemplary and not limiting embodiment including a plurality of remote sites 200a, 200b, ... 200n.

Central station 100 exchanges commands and data with each remote site 200 over a communication link 400. As shown in Fig. 1, communication link 400a couples central station

100 with remote site 200a, communication link 400b couples central station 100 with remote site 200b, and communication link 400n couples central station 100 with remote site 200n. It will be understood that for each remote site 200 provided by system 10, a communication link 400 will couple that remote site 200 to central station 100.

Using communication link 400, the central station 100 transmits commands and configuration data to each remote site 200, and receives data sampled and gathered at each remote site 200. Typically, central station 100 is located at a hospital or clinic, where patient support staff or nursing personnel are gathered. Remote site 200 is a patient location where patient status is to be monitored. A remote site 200 is typically located either at a patient's home or at a satellite location within a hospital or clinic. Remote site 200 could also be a patient bed area within a hospital or nursing home. System 10 allows personnel at central station 100 to remotely monitor and track multiple patients located at remote sites 200. According to several embodiments of the invention, the communication link 400 is implemented with POTS lines, ISDN lines, WANs, LANs, Intranet links, Internet links, a dial-up telephone line, or other communication lines.

The components and operation of central station 100 and an exemplary remote site 200 are described in more detail below.

Fig. 2 is a block diagram of a remote site 200 as shown in Fig. 1. It should be understood that in Fig. 2 and the other drawing figures, a single communication line is shown between certain entities for convenience of illustration. It should also be understood further that several parallel communication lines could be used in alternative embodiments.

In a minimum configuration, a remote site 200 includes a patient monitoring unit 214 and a garment 216 housing a plurality of sensors 218 and adapted to be worn by a patient. In this minimum configuration, patient monitoring unit 214 receives readings from sensors 218, and communicates these readings directly to central station 100. Patient monitoring unit 214 also receives commands from central station 100, for example to take readings from a specific one of sensors 218.

In the exemplary embodiment shown in Fig. 2, each remote site 200 includes at least a personal computer (PC) 202, a security system 226, a serial interface box 208, a patient monitoring unit 214, a medication dispensing unit 212, and a garment 216 adapted to be worn by a patient. Each of these components is described in detail below, along with their associated subcomponents. Depending on the requirements of a given remote site 200, one or more of the

components shown in the exemplary embodiment of Fig. 2 can be omitted, such as environmental control system 210, medication dispensing unit 212, door sensor 220, window sensor 222, motion and non-motion detection sensors 224 and 240, or security system 226 and its related sub-components.

PC 202 is coupled to central station 100 by communication link 400 to exchange control signals, data signals, and alert signals with central station 100. In an exemplary embodiment, PC 202 is an IBM-compatible PC equipped with at least a Pentium™ microprocessor, approximately 128Kb of memory, approximately 500Mb of hard disk capacity, a serial port, and a communications modem of at least 28.8 baud capacity. It is within the scope of the invention to modify the specific configuration of PC 202 to support the remote site 200. Alternatively, PC 202 may be a personal-type computer manufactured by other vendors, such as Apple Corporation. As shown in Fig. 2, PC 202 exchanges both control and data signals with central station 100, and sends alert signals to central station 100 to command the attention of support personnel, when an emergency or other urgent condition occurs.

PC 202 operates with a suitable operating system, such as Windows NT, developed and sold by Microsoft Corporation of Redmond, Washington, and a database management package such as SQL Server, also developed and sold by Microsoft Corporation. The operating system running aboard the PC 202 supports multitasking, in an exemplary embodiment.

Serial interface box 208 is coupled to the serial port of PC 202. Because conventional PC architecture can monitor and service only a limited number of serial communication ports (typically up to four with only two interrupts), serial interface box 208 extends the number of serial devices that PC 202 can service. A suitable serial interface box 208 is the model CPM series of control port managers manufactured by Western Telematic, Inc. of Irvine, CA. In an exemplary embodiment, serial interface box 202 used RS-232 protocol, but in certain application, other serial protocols may be suitable.

Serial interface box 208 includes one common port 208a coupled to a serial port of the PC 202 and a plurality of device ports 208b, with each one of the device ports 208b coupled to a sensor or monitoring device. In the exemplary and not limiting embodiment shown in Fig. 2, serial interface box 208 is coupled to serial devices such as environmental sensors 204, biosensors 206, environmental control system 210, patient monitoring unit 214, medication dispensing unit 212, door sensor 220, window sensor 222, motion detector 224, and non-motion detector 240. In this manner, the serial interface box 208 multiplexes several serial devices onto the serial communication link coupling PC 202 to serial interface box 208.

PC 202 controls serial interface box 208 and directs it to connect one of the multiplexed serial devices to the serial port of PC 202. In an exemplary embodiment, serial interface box 208 maintains a look-up table mapping each device ports 208b to a given multiplexed serial device. When the serial device coupled to a given device port 208b generates an interrupt, serial interface box 208 looks up the interrupting device port 208b in the table, and generates an appropriate interrupt to PC 202.

As discussed above, serial interface box 208 may be coupled to one or more of a plurality of multiplexed serial devices, including biosensors 206, environmental sensors 204, environmental control system 210, patient monitoring system 214, door sensor 220, window sensor 222, motion detector 224, and non-motion detector 240. Biosensors 206 and environmental sensors 204 are illustrated and discussed in more detail below in Fig. 7. Environmental control system 210 is illustrated and discussed in more detail below in Fig. 3.

Door sensor 220 detects the opening and closing of any doors leading to the patient's room. By tracking when the open/close status of the doors, door sensor 220 can assist in locating the patient and can detect when other persons have entered the patient's room. Similarly, window sensor 222 detects the opening and closing of any windows in a patient's room.

Motion detector 224 provides a signal indicating movement within the patient's room. Suitable motion detectors are commercially available and typically operate using infrared beams or sound waves. PC 202 monitors the signal from motion detector 224 to ensure that the patient is active. When there is no signal from motion detector 224 for some time interval, PC 202 concludes that the patient is inactive and possibly in danger, and issues appropriate alerts to central station 100. Conversely, where it is preferable to detect when there has been no motion in the room over some time interval, a non-motion detector 240 can be coupled to serial interface box 208. Non-motion detector 240 signals when there has been no motion within the room over some time interval. Using one or both of these detectors, PC 202 can monitor whether the patient has not moved over a given time interval, and issue appropriate alerts as dictated by the patient's activity level and programmed into patient monitoring system 10.

Patient monitoring unit 214 is coupled to one of the device ports 208b provided by serial interface box 208 and communicates with the PC 202 through serial interface box 208. Patient monitoring unit 214 functions to monitor the vital signs of the patient located at remote site 200. When the vital signs of the patient fall outside certain thresholds, possibly indicating that the patient is in discomfort, in danger, or in need of attention, patient monitoring unit 214 generates a nurse-call signal on line 214a. The nurse-call signal alerts medical support personnel that the

patient demands immediate attention. Also, patient monitoring unit 214 supplies raw signals representing the patient's vital signs to PC 202 via serial interface box 208. PC 202 processes these signals to determine the status of the patient independently of patient monitoring unit 214. In this manner, PC 202 provides redundant monitoring of the patient, so that if patient monitoring unit 214 or PC 202 fails, the other provides back-up patient monitoring.

A suitable patient monitoring unit 214 is the Welch-Allyn LifeSign™ unit. The LifeSign™ unit measures the patient's blood pressure and pulse rate, and provides programmable alarms for high and low systolic and diastolic blood pressure and pulse rate. The LifeSign™ unit provides both visual and audio alarms, and stores monitoring data in memory and on hardcopy. The LifeSign™ unit also allows programming of the pressure to which the blood pressure cuff's is inflated, and monitors pulse oximetry as well.

Security system 226 may be coupled to PC 202, to serial interface box 208, and to patient monitoring unit 214. Security system 226 is also coupled directly to central station 100 by a dedicated alert link 226a. Using this dedicated alert link 226a, security system 226 can bypass PC 202 and alert central station 100 directly. Security system 226 is coupled to receive the nurse-call signal on line 214a, and can alert central station 100 in response to the nurse-call signal. Security system 226 is coupled to alert PC 202 when it receives the nurse-call signal on line 214a. This dual-notification structure between PC 202 and security system 226 provides separate redundant paths by which to notify central station 100 when the patient needs attention. If security system 226 or dedicated alert link 226a between security system 226 and central station 100 fails, the link between PC 202 and central station 100 provides a back-up communication link. Conversely, if the link between PC 202 and central station 100 fails, then dedicated alert link 226a between security system 226 and central station 100 provides a back-up communication link.

Security system 226 functions generally to monitor the status of the patient and the patient's environment, and to generate alert signals when necessary. A suitable security system 226 is one of the ESPIRIT line of control panels manufactured by Paradox Security Systems, Inc.. The ESPIRIT line of control panels provides integrated keypads for the entry of security codes, and these control panels are configured to monitor a plurality of security zones.

Security system 226 is coupled to a plurality of subcomponents, including a battery backup system 228, a heat sensor 230, an emergency pendant 238, a display 234, and a keypad

232. Battery backup system 228 provides an alternate power supply should the primary AC power supply at the remote site 200 fail.

Heat sensor 230 monitors the ambient temperature of the patient's room and generates appropriate alerts when the ambient temperature is either too high or too low. A suitable heat sensor 230 is the Intellitemp T-1000 manufactured by Intellisense™ Systems, Inc. of Louisville, KY.

Emergency pendant 238 is adapted for carrying by the patient, and is coupled to the security system 226 by a direct wire or a wireless communication link. When the patient requires immediate assistance and cannot speak or otherwise signal his or her distress, the patient presses a button on emergency pendant 238 to notify security system 226 (and ultimately central station 100) of his or her distress. The Linear Corporation of Vista, CA provides a DXR-701 digital receiver, along with a hand-held transmitter unit compatible with the DXR-701. The hand-held transmitter unit can provide a suitable emergency pendant 238, if the DXR-701 digital receiver is coupled to the security system 226.

Garment 216 is adapted to house at least one patient sensor 218, and patient sensor 218 is coupled through a connector 215 to patient monitoring unit 214. The physical structure of garment 216 is illustrated and described below with respect to Fig. 6.

Medication dispensing unit 212 communicates with serial interface box 208 to receive commands from PC 202, and to transfer signals representing the status of medication doses to PC 202. Medication dispensing unit 212 is described in more detail below with respect to Figs. 8-15 below. It should also be understood that in an alternate embodiment of the invention, medication dispensing unit 212 can function as a stand-alone unit separate from remote patient monitoring system 10.

In an exemplary embodiment, system 10 provides a video link 408 between central station 100 and each remote site 200 where it is necessary or desirable to have video communication with a remote site 200. Video link 408 allows patients to observe medical personnel demonstrate use of medical devices or diagnostic equipment. In addition, the medical personnel can directly observe the patients to ensure that they properly take medication, that they are in generally good or bad condition, that they are coherent, among other observations.

Visual communication device or means 300a, such as a VIA-TV phone, is provided at remote site 200 with a corresponding visual communication device 300b at central station 100. In an exemplary embodiment, visual communication devices 300 are transceivers capable of

transmitting and receiving both image and audio signals. Visual communication device 300a is connected to central station 100 by video link 408, over which video and/or image data is exchanged. Video link 408 may include both dedicated and multiplexed communication lines, which are implemented with the same technologies discussed above with respect to communication links 400. It should be understood that if multiple remote sites 200 are equipped with visual communication devices 300a, then the visual communication device 300b located at central station 100 is coupled to each of the visual communication devices 300a that are provided at remote sites 200.

Fig. 3 is a block diagram illustrating the various components of environmental control system 210 illustrated in Figure 2. As shown in Figure 3, environmental control system 210 interfaces with serial interface box 208 over a control line 332 and a bi-directional data line 334. Environmental control system 210 generally includes several control devices, such as an environmental system controller 302, a climate control 304, a door control 306, a lighting control 308, a bed adjustment control 310, an oxygen concentration control 312, an IV flow rate control 314, and a video monitoring unit 316. Environmental system controller 302 is typically a microcontroller programmed to interact with serial interface box 208, and to control each of the control devices shown in Figure 3, according to instructions received through serial interface box 208. Climate control 304 adjusts the heating, cooling and ventilation within the patient's room. As such, climate control 304 may control the operation of ventilation systems in the room including ceiling fans, ceiling ventilators, or window ventilators in order to enhance the patient's comfort. Climate control 304 also interfaces with the heating, ventilation, air conditioning (HVAC) thermostat system within the room to regulate the temperature in the room as necessary. In this manner, the climate within the patient's room can be controlled remotely through the environmental control center 210 by passing commands through serial interface box 208.

Door control 306 regulates access to the patient's room. According to one aspect of the invention, the doors leading into the patient's room are equipped with electromagnetic or other door locks 322 that are operable by door control 306. Door control 306 responds to commands from environmental system controller 306 engage door lock 322. In this manner, personnel at central station 100 can regulate access to the patient's room by activating or deactivating door control 306, thereby enhancing patient security by controlling door lock 322. Door control 306 may be most suitable for a hospital or nursing home setting.

Lighting control 308 interfaces with environmental system controller 302, and controls at least one light switch 324 to adjust the level of lighting within the patient's room. In this matter,

personnel in central station 100 can regulate the level of lighting in the room, turning on certain lights and turning off others as necessary to observe the patient or to enhance the patient's comfort. Light switch 324 can be an on-off switch or a dimmer switch. Lighting control 308 may be most suitable for a hospital or nursing home setting.

Bed adjustment control 310 interfaces with environmental system controller 302 to control the position and configuration of the patient's bed. As understood by those skilled in the art, hospital beds are often provided with electrically operated motors 326 that configure different portions of the bed, depending on the patient's comfort level and medical necessity. Bed adjustment control 310 provides an interface to these motors 326 and enables environmental system controller 302 to regulate the position of the bed. In this matter, personnel at central station 100 can adjust the bed remotely to enhance patient comfort and to promote recovery. Bed adjustment control 310 may be most suitable for a hospital or nursing home setting.

Oxygen concentration control 312 interfaces with environmental system controller 302 to control the level of oxygen in the patient's room by regulating oxygen supply 328. Oxygen concentration control 312 includes a sensor that indicates the level of oxygen within the room, and communicates that information to central station 100 through environmental system controller 302 and serial interface box 208. Certain patients, especially recovering pulmonary and respiratory patients, may require enhanced levels of oxygen in their environment during recovery and rehabilitation. For such patients, it may be necessary to provide supplemental oxygen through a nasal cannula if the oxygen level in the ambient air is insufficient. Oxygen concentration control unit 312 is coupled to such a nasal cannula and regulates the oxygen level provided in the nasal cannula.

IV flow rate control 314 interfaces with environmental system controller 302, and controls IV fluid supply 330 to adjust the rate of flow of IV fluids. In this manner, personnel at the central station 100 can remotely control the flow rate of IV fluids to the patient.

In an additional embodiment of the invention, a video monitoring unit 316 is provided to interface with environmental system controller 302, thereby providing a video link between the patient's room and central station 100. This video link is especially useful to facilitate visual contact and interaction between the support staff and the patient.

Fig. 4 is a diagram illustrating how central station 100 and remote site 200 are coupled to exchange data. The components of central station 100 shown in Fig. 4 are central server 402, personnel alert interface 404, audio interface 406a and visual communication device 300b. The

components of remote site 200 shown in Fig. 4 are PC 202, security system 226, audio interface 406b, and visual communication device 300a.

Visual communication devices 300a and 300b are linked by a dedicated video link 408, which allows the two interfaces to communicate directly. In this manner, nursing personnel at central station 100 can directly monitor the patient at remote monitoring site 200 via video link 408. A suitable system for implementing visual communication devices 300a, 300b, and video link 408 is the VIA TV phone model 1905, manufactured by 8 X 8, Inc. of Santa Clara, CA.

Audio link 406 links audio interfaces 408a and 408b, allowing audio communication between central station 100 and remote monitoring site 200. Dedicated audio link 406 provides another redundant level of communication between central station 100 and remote monitoring site 200.

In additional embodiments of the invention, personnel alert interface 404 is a speaker, a computer monitor capable of displaying suitable messages, a buzzer, or other communication interfaces.

The remote patient monitoring system enhances patient monitoring by providing redundant alert links between remote site 200 and central station 100. At remote site 200, security system 226 and PC 202 are coupled to personnel alert interface 404 at central station 100 by two redundant alert links. Dedicated alert link 410 links security system 226 directly to personnel alert interface 404, while software alert link 414 connects PC 202 to the personnel alert interface 404. Furthermore, security system 226 is linked to PC 202 by cross-link 412.

Security system 226 and PC 202 each independently monitor the status of the patient's vital signs at remote site 200 using separate sets of sensors. When PC 202 senses data indicating that the patient requires urgent attention, it generates an alert signal along software alert link 414 to personnel alert interface 404 at central station 100. PC 202 also generates a signal on cross-link 412 to security system 226, causing security system 226 to generate an alert signal on dedicated alert link 410 to personnel alert interface 404.

Using two redundant alert links, remote site 200 provides two alert signals to central station 100, one along software alert link 414 and another along dedicated alert link 410. Should one of the links fail, the other link serves as a back-up, thereby insuring that the personnel at central station 100 are notified of the urgency to attend to the patient at remote site 200. Likewise, should security system 226 detect that the patient needs urgent attention, it can generate an alert signal along its dedicated alert link 410, and can also generate appropriate alert signals

along cross-link 412 to PC 202. PC 202 can then generate a redundant alert signal along its software alert link 414, thereby providing two alert signals to the personnel at central station 100.

In an exemplary embodiment, PC 202 is equipped with video software 202a, alert generation software 202b, database 202c, and communication port 202d. At central station 100, central server 402 is equipped with video software 402a, which is linked to video software 202a on PC 202 via software video link 418. Suitable video software is the ProShare product from Intel Corporation.

Central server 402 is also equipped with medical charting software 402b, database 402c, and a receiver unit 402d. Communication port 202d is linked to receiver unit 402d by a patient data link 416. Medical charting software 402b receives data from database 402c.

Suitable receiver units 402d are the SG-SLR single-line digital receiver and the MLR2-DG multi-line digital receiver, both manufactured by Sur-Gard Security Systems LTD of Montreal, Canada.

Figure 5 is a diagram of the several patient sensors 218 coupled to garment 216, as shown in Figure 2. Figure 5 illustrates several exemplary sensors that can be provided as patient sensors 218. In the exemplary and not limiting embodiment shown in Fig. 5, patient sensors 218 refer collectively to blood pressure sensor 500, pulse rate sensor 502, respiration rate sensor 504, body temperature sensor 506, position sensor 508, GPS monitor 510, and seizure monitor 512. It should be understood that at least one sensor is housed in garment 216, with the number and type of sensors chosen as appropriate for a given application.

Several examples of optional sensors 218 are now discussed separately. Sensor 500 senses the patient's blood pressure, and may be a blood pressure cuff or other suitable device for measuring blood pressure. Sensor 502 monitors the patient's pulse rate. Sensor 504 monitors the patient's rate of respiration. Sensor 506 monitors the patient's body temperature. Sensor 508 monitors the patient's position and indicates if the patient has fallen. Sensor 510 is a monitor that interacts with a global positioning system (GPS). GPS monitor 510 can be used to track the patients whereabouts with precision and to locate and direct a lost or disoriented patient. Seizure monitor 512 senses whether the patient is having any type of a seizure, for example by monitoring the brain activity of the patient.

Fig. 6 is a diagram of an exemplary garment 216 in accordance with the present invention. Garment 216 is adapted to house at least one sensor 218, and sensor 218 is coupled to the connector 215. Connector 215 provides a medium through which the sensor 218

communicates with patient monitoring unit 214. Garment 216 includes a sleeve portion 602 adapted to fit the patient's upper arm, and a torso portion 604 adapted to fit the patient's upper body. Sleeve portion 602 includes a pouch 606 adapted to receive a blood pressure cuff (not shown) to monitor the patient's blood pressure.

Garment 216 promotes remote patient monitoring by allowing the patient to properly locate sensor 218 by putting on garment 216 and wearing it. Once garment 216 is sized to fit a given patient, and is fitted appropriately with sensor 218, the patient can wear garment 216 and simultaneously locate sensor 218 properly. In additional embodiments, garment 216 can be fitted with a plurality of sensors 218 to monitor various patient vital signs, depending on the patient's medical condition. Once garment 216 is equipped with sensor 218 and fitted to a given patient, medical support personnel no longer need to travel to the remote site 200 to position sensor 218 on the patient's body.

Torso portion 604 and/or sleeve portion 602 define a channel 610 linking connector 215 to each of the sensors 218. Garment 216 promotes remote patient monitoring by allowing the patient to properly locate the sensors on the patient's torso. Channel 610 houses a signal transmission conduit 612 that couples each of sensors 218 to connector 215. Depending on the requirements of a given application, signal transmission conduit 612 may be an electrical conductor or a blood pressure tube coupled to the blood pressure cuff housed in pouch 606.

Depending on the patient monitoring designated for a particular patient, sensors 218 housed in garment 216 can be bio-sensors, including but not limited to EKG sensors, spirometers, and glucometers. Garment 216 is configured to place each sensor 218 in communication with the body of the patient, as required by the characteristics of a particular sensor 218.

Depending on the patient monitoring designated for a particular patient, garment 218 is equipped with a speaker 614, a microphone 616, and at least one conductor 618 coupling speaker 614 and microphone 616 to connector 215. It should be understood that Fig. 6 illustrates speaker 614, microphone 616, and sensor 218 in exemplary and not limiting positions. Using speaker 614 and microphone 616, central station 100 can communicate with the patient to long as the patient is wearing garment 218. If a wireless link exists between connector 215 and patient monitoring unit 214, then the patient is free to move away from patient monitoring unit 214 without losing contact with central station 100.

Patient monitoring unit 214 communicates with sensor 218 through connector 215, and is configured to transmit signals from sensor 218 to PC 202 for recording. In an exemplary

embodiment, connector 215 is physically connected to patient monitoring unit 214. Alternatively, connector 215 can communicate with patient monitoring unit 214 through an RF or other wireless, electromagnetic link. With either embodiment, the patient is free to selectively disconnect connector 215 from patient monitoring unit 214. In the former embodiment, data does not flow between the sensor 218 and the patient monitoring unit 214 until the connection is re-made, but with the latter embodiment, data can flow at all times.

Connector 215 promotes remote patient monitoring by providing a quick-connect, quick-disconnect means allowing the patient freedom of movement while still allowing central station 100 to monitor the patient's vital signs. Connector 215 is described in more detail in connection with Fig. 21 below.

Typically, patient monitoring unit 214 is located at the patient's bedside. Patient monitoring unit 214 is also configured to exchange signals representing patient status with central station 100, where nursing or other hospital personnel are located.

Figure 7 is a diagram of several exemplary sensors that comprise biosensors 206 and environmental sensors 204 as shown in Figure 2. Biosensors 206 and environmental sensors 204 are coupled to communicate with remote site 200 through serial interface box 208. Biosensors 206 may include, but are not limited to oxygen saturation sensor 700 to measure to oxygen level in the patient's bloodstream, electrocardiogram (ECG) 702 to measure the patient's cardiac activity, stethoscope 704, glucometer 706, and spirometer 708. Each of these bio-sensors 206 are coupled to serial interface box 208 to enable them to communicate with the rest of the system, especially patient monitoring unit 214 and PC 202.

Environmental sensors 204 may include, but are not limited to room temperature sensor 710, barometric pressure sensor 711, humidity sensor 712, carbon monoxide sensor 714 and smoke sensor 716. Room temperature sensor 710 and humidity sensor 712 sense the ambient temperature and humidity, respectively, in the patients room. The Perception II® unit manufactured by Davis Instruments provides an indoor temperature, barometric pressure, and humidity sensor that is suitable as room temperature sensor 710, barometric pressure sensor 711, and humidity sensor 712. Davis Instruments also provides Weather Link® software to collect, organize, and export data representing the climate conditions within a patient's room. Carbon monoxide sensor 714 monitors the level of carbon monoxide accumulating in the patient's room and generates a suitable alarm should the carbon monoxide level become hazardous. Carbon monoxide sensor 714 also provides a signal through serial interface box 208 indicating the level of carbon monoxide in the room so that air quantity can be monitored at central station 100. Smoke

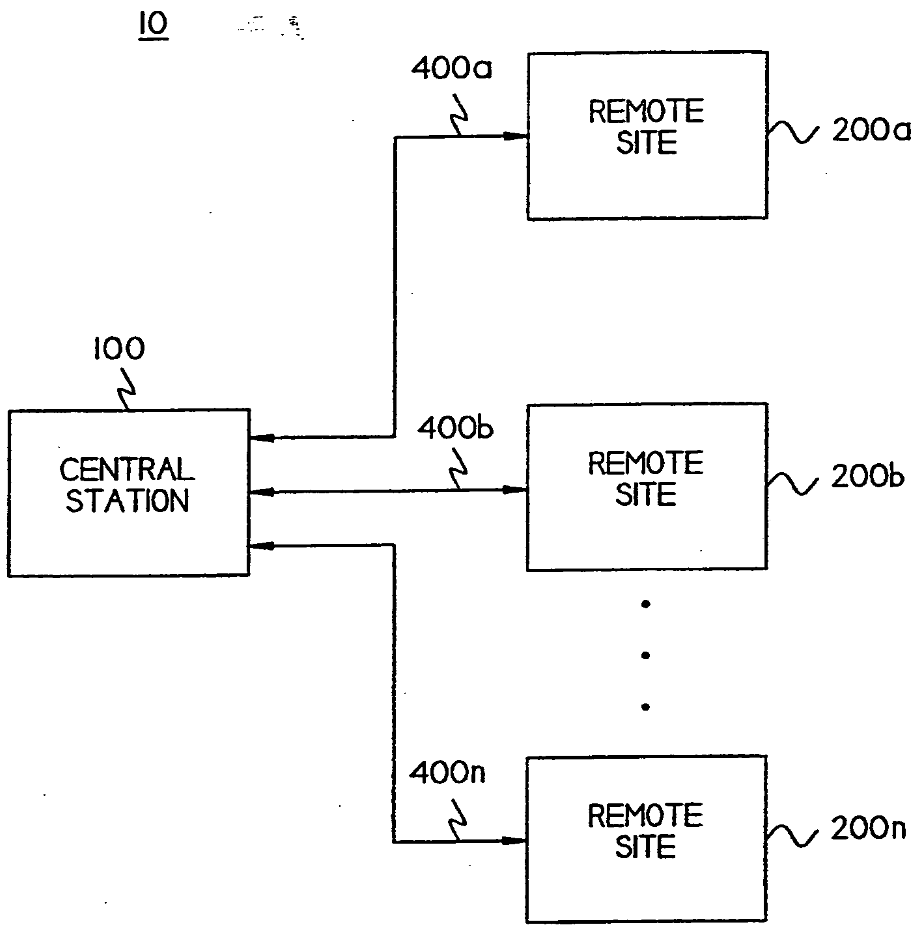

10
400a
REMOTE SITE
200a
100
CENTRAL STATION
400b
REMOTE SITE
200b
400n
REMOTE SITE
200n

FIG. 1

FIG. 2

FIG. 2A
FIG. 2B

FIG. 2A

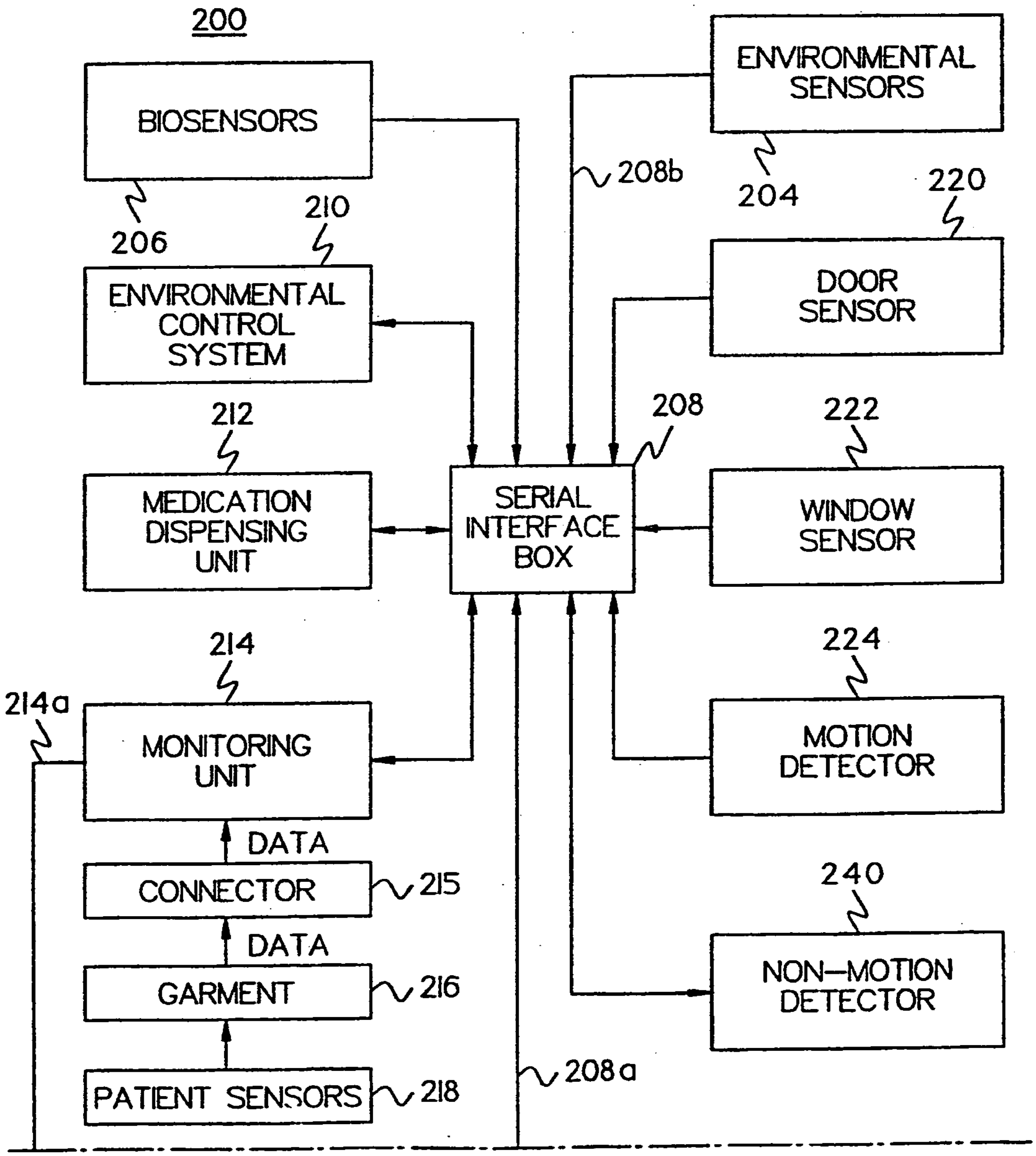
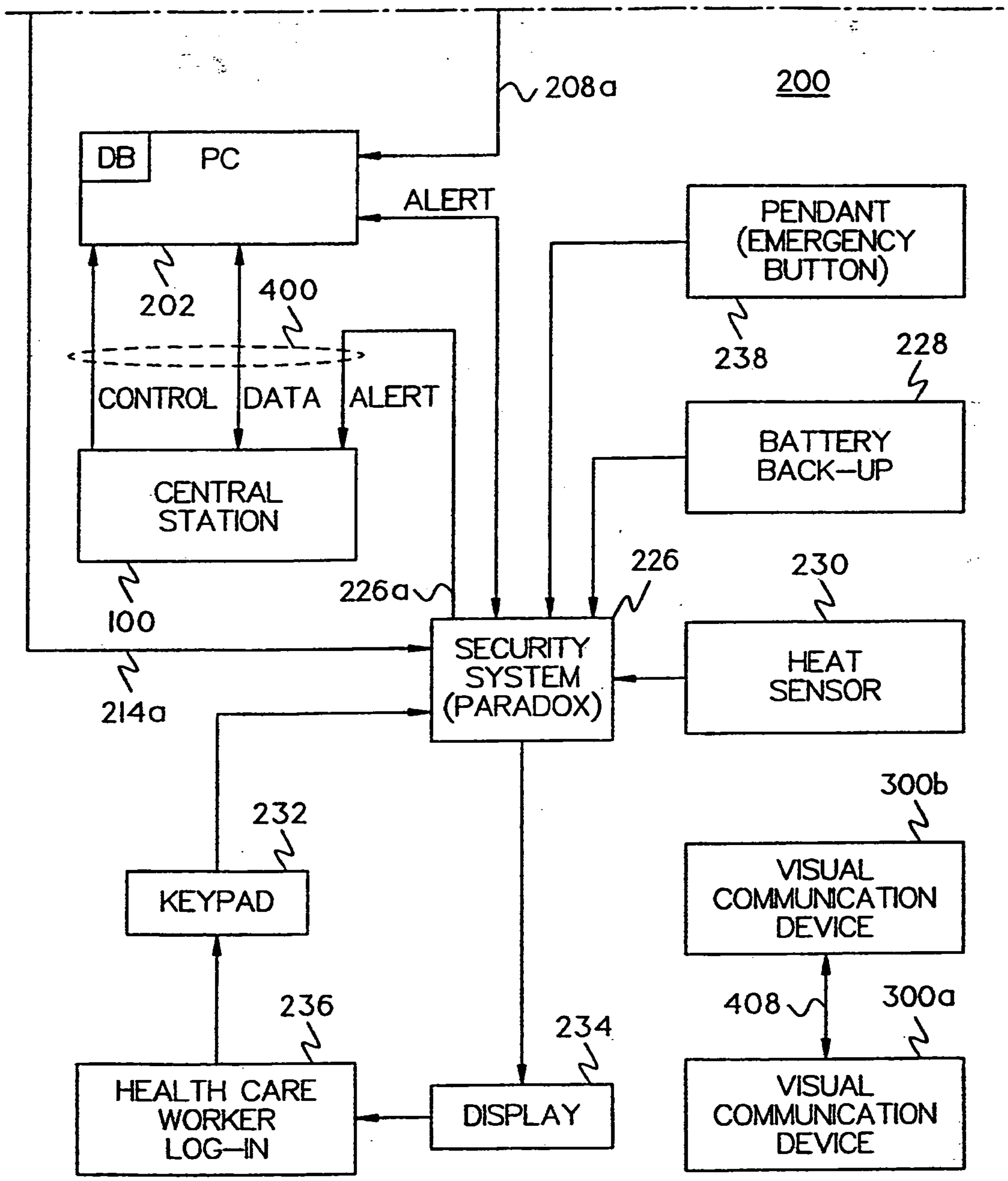


FIG. 2B


208a
200
DB
PC
ALERT
PENDANT (EMERGENCY BUTTON)
202
400
238
228
CONTROL
DATA
ALERT
BATTERY BACK–UP
CENTRAL STATION
226
230
226a
100
SECURITY SYSTEM (PARADOX)
HEAT SENSOR
214a
300b
232
KEYPAD
VISUAL COMMUNICATION DEVICE
236
408
300a
234
HEALTH CARE WORKER LOG–IN
DISPLAY
VISUAL COMMUNICATION DEVICE

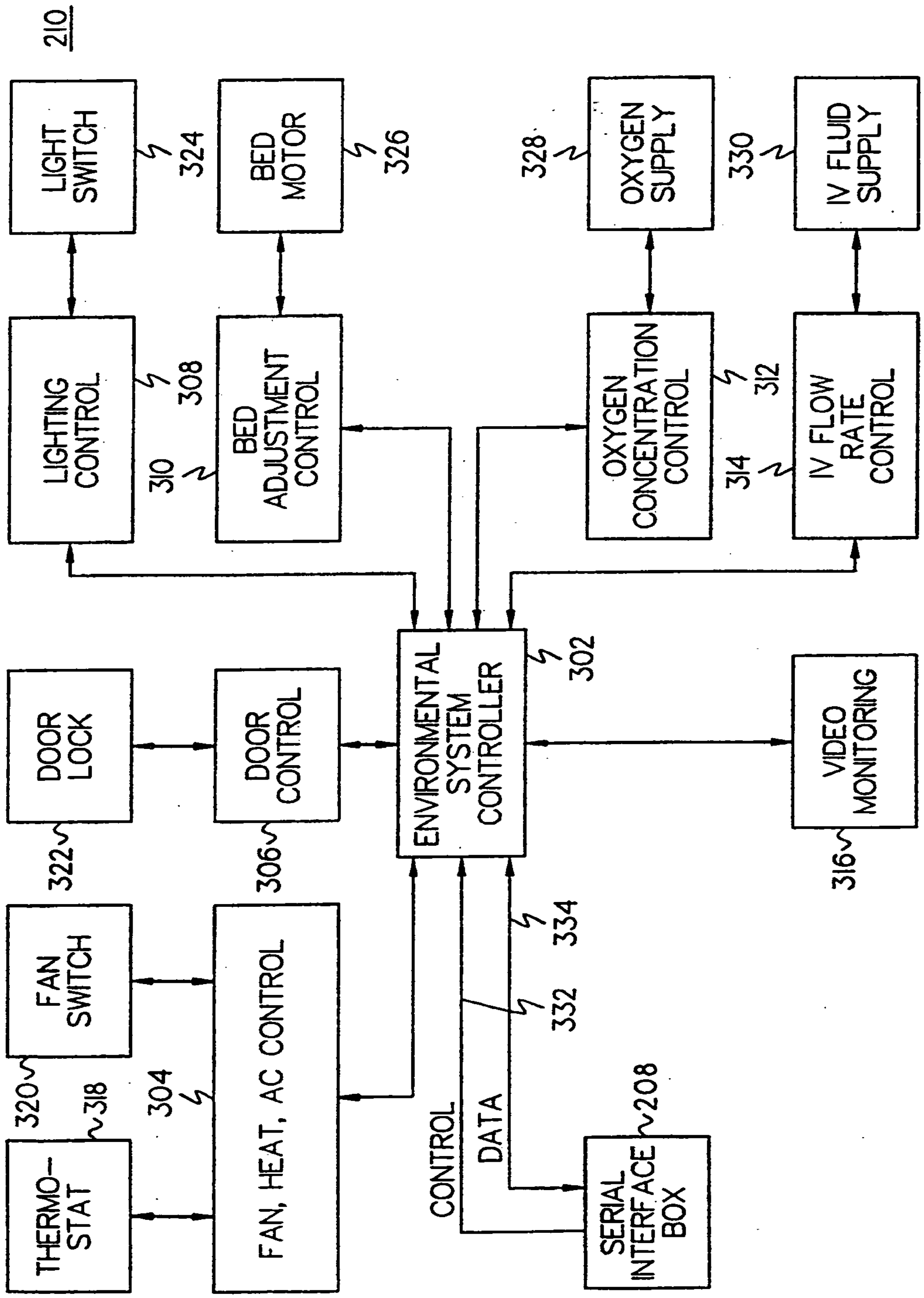

210
LIGHT SWITCH
324
BED MOTOR
326
328
OXYGEN SUPPLY
330
IV FLUID SUPPLY
LIGHTING CONTROL
308
310
BED ADJUSTMENT CONTROL
OXYGEN CONCENTRATION CONTROL
312
314
IV FLOW RATE CONTROL
DOOR LOCK
DOOR CONTROL
ENVIRONMENTAL SYSTEM CONTROLLER
302
VIDEO MONITORING
322
306
316
FAN SWITCH
334
332
320
318
304
THERMO-STAT
FAN, HEAT, AC CONTROL
CONTROL
DATA
208
SERIAL INTERFACE BOX

FIG. 3

FIG. 4

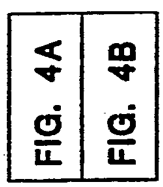


FIG. 4A
FIG. 4B

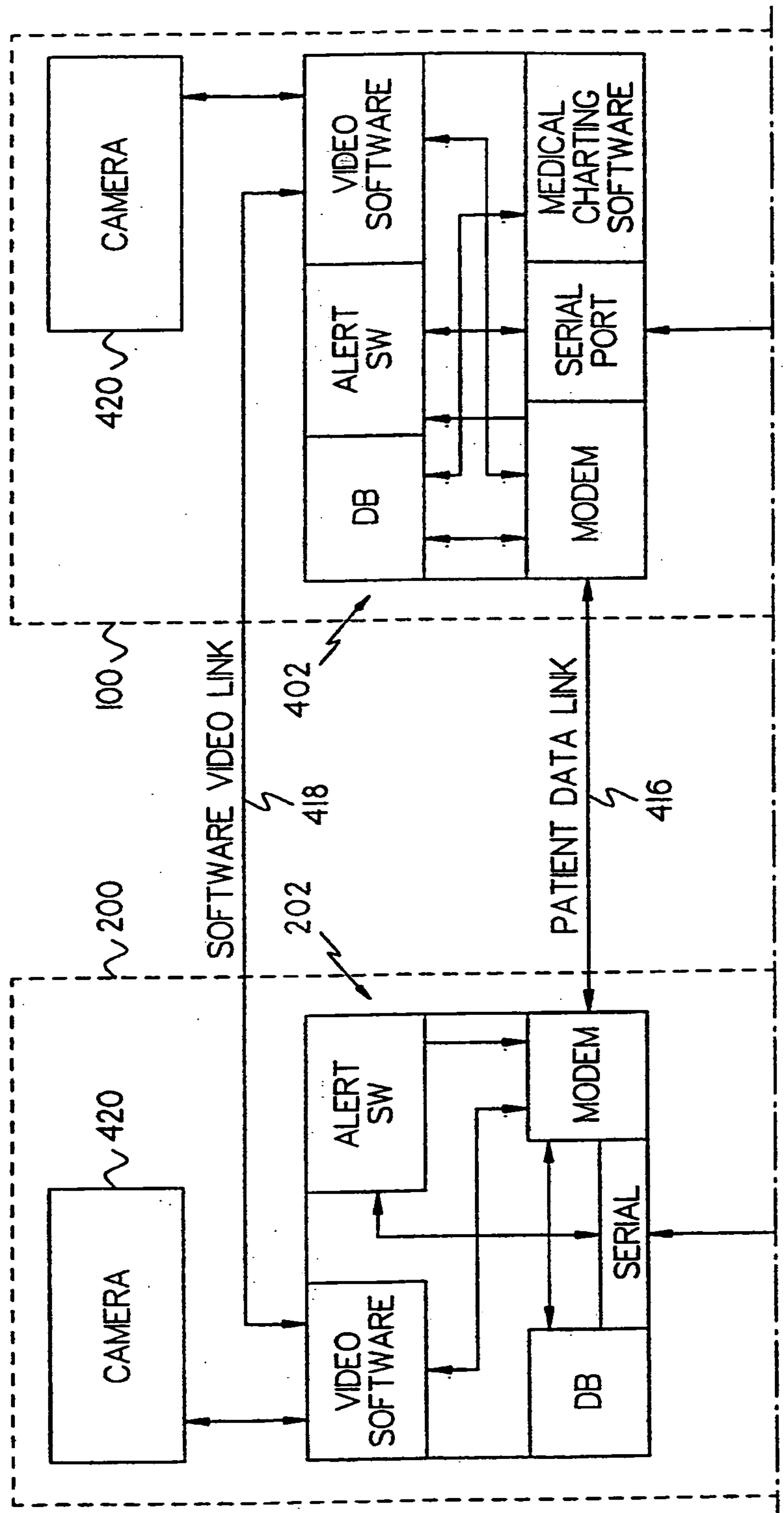
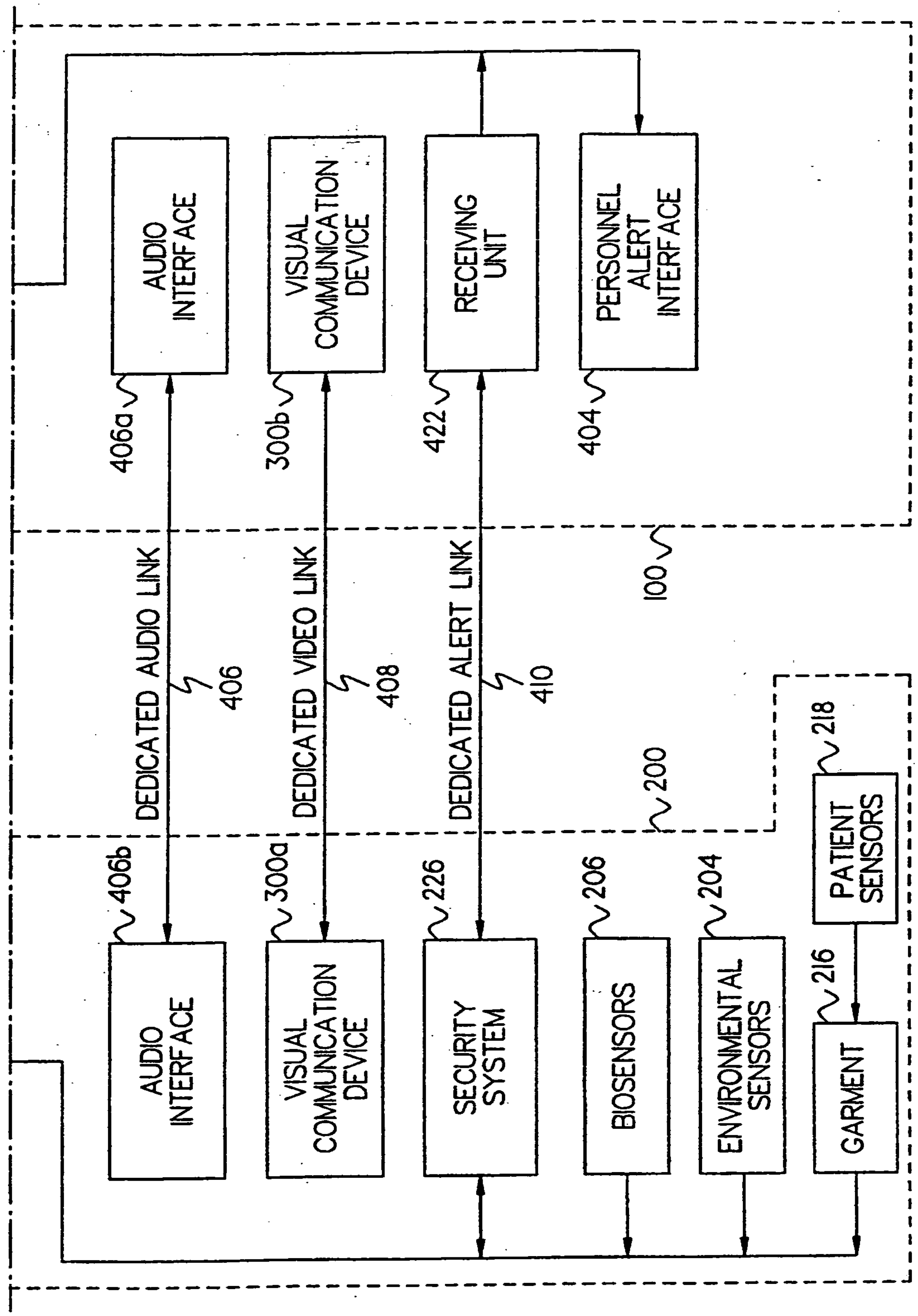

CAMERA
VIDEO SOFTWARE
MEDICAL CHARTING SOFTWARE
ALERT SW
SERIAL PORT
DB
MODEM
420
100
402
SOFTWARE VIDEO LINK
418
PATIENT DATA LINK
416
200
202
ALERT SW
MODEM
420
SERIAL
CAMERA
VIDEO SOFTWARE
DB

FIG. 4A

FIG. 4B


AUDIO INTERFACE
VISUAL COMMUNICATION DEVICE
RECEIVING UNIT
PERSONNEL ALERT INTERFACE
406a
300b
422
404
DEDICATED AUDIO LINK
406
DEDICATED VIDEO LINK
408
DEDICATED ALERT LINK
410
100
200
406b
300a
226
206
204
218
216
AUDIO INTERFACE
VISUAL COMMUNICATION DEVICE
SECURITY SYSTEM
BIOSENSORS
ENVIRONMENTAL SENSORS
PATIENT SENSORS
GARMENT

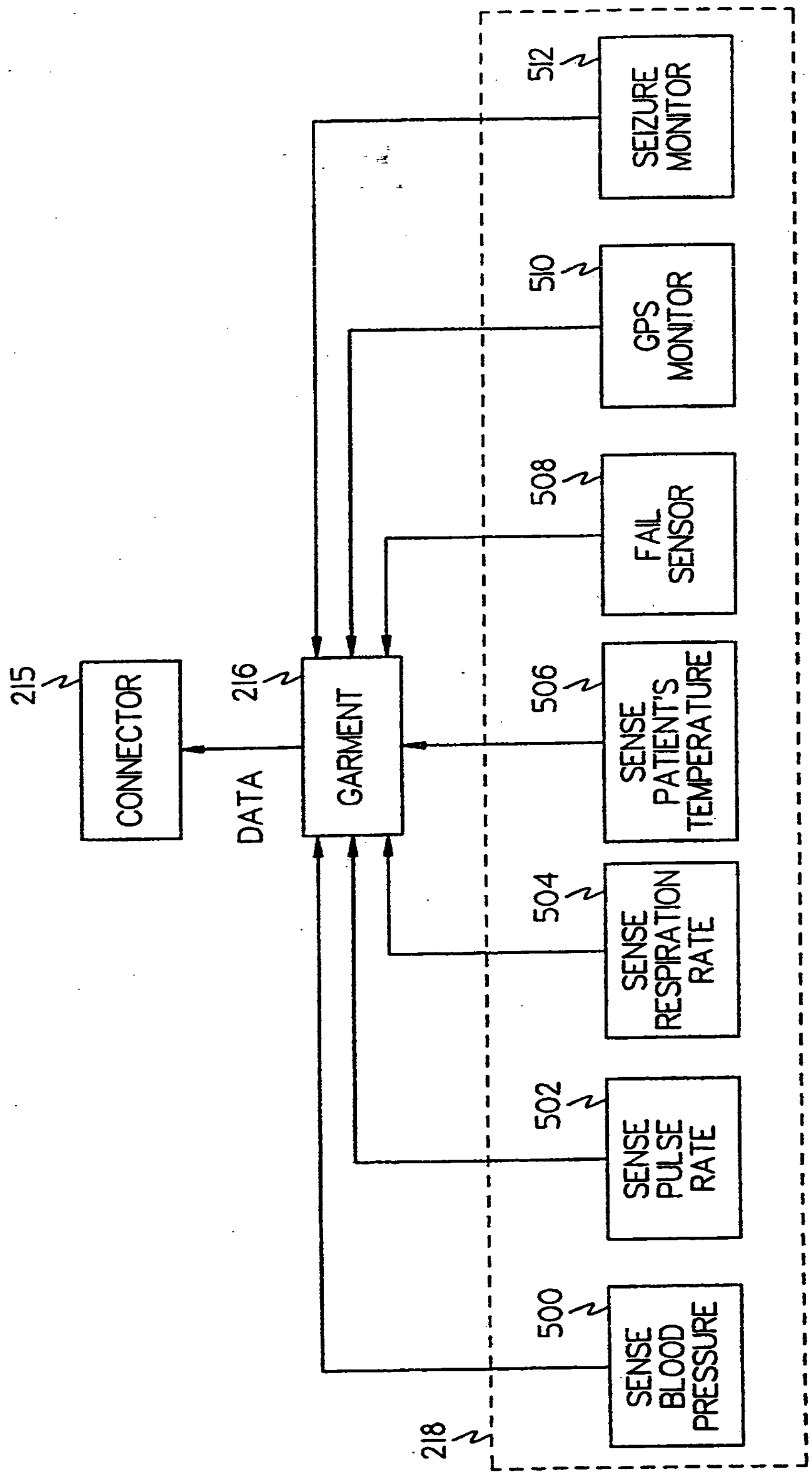

215
CONNECTOR
216
GARMENT
DATA
218
500
SENSE BLOOD PRESSURE
502
SENSE PULSE RATE
504
SENSE RESPIRATION RATE
506
SENSE PATIENT'S TEMPERATURE
508
FAIL SENSOR
510
GPS MONITOR
512
SEIZURE MONITOR

FIG. 5

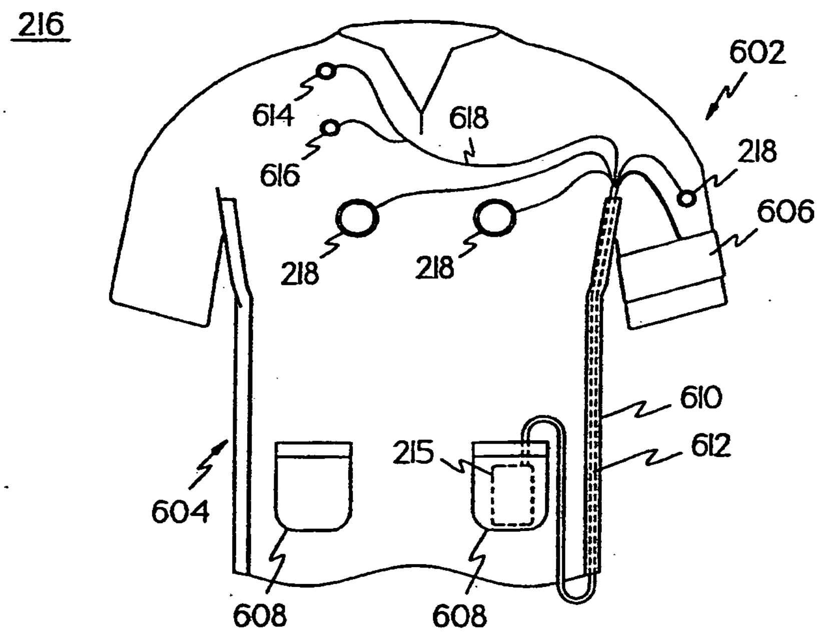


FIG. 6

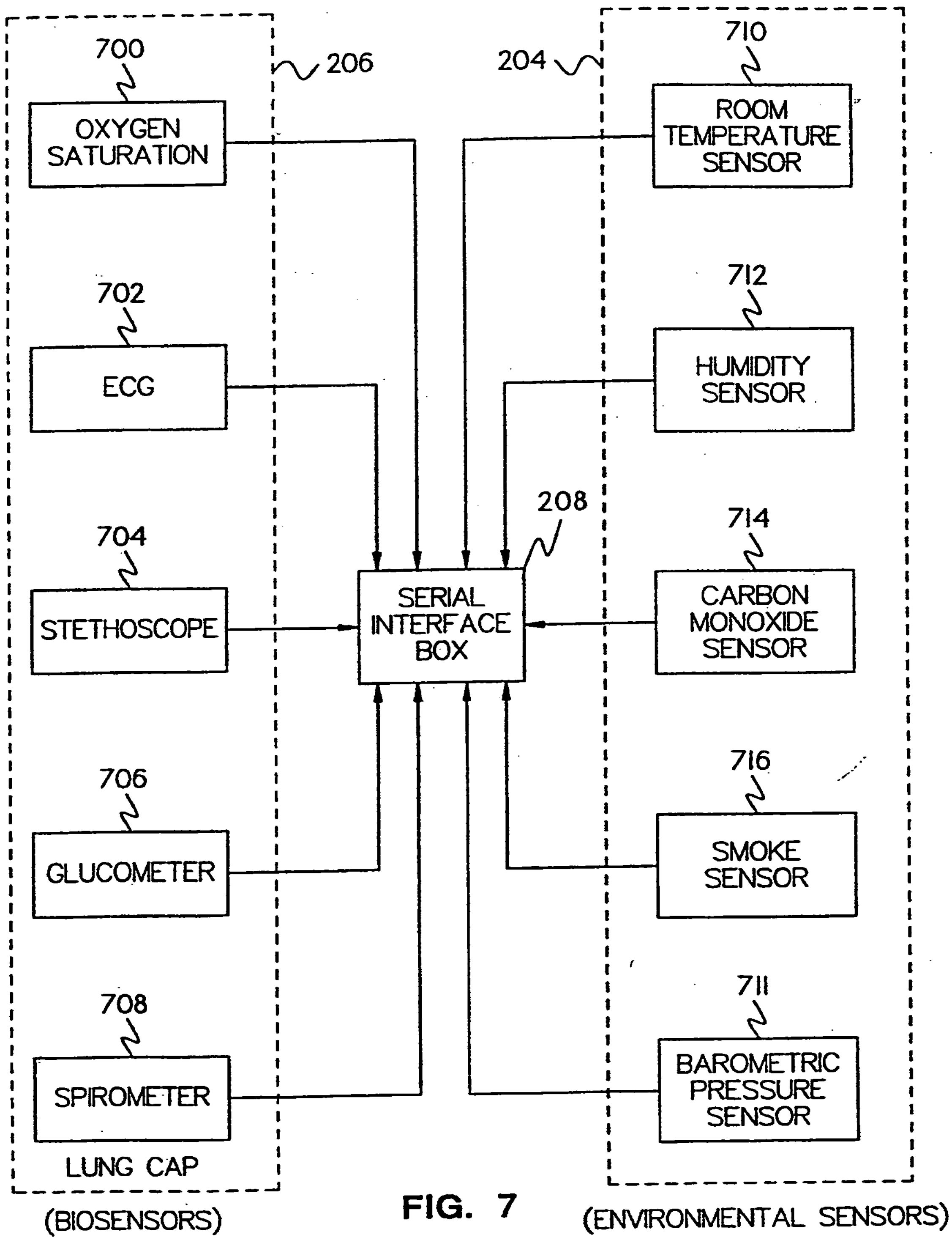

700
OXYGEN SATURATION
702
ECG
704
STETHOSCOPE
706
GLUCOMETER
708
SPIROMETER
LUNG CAP
206
204
208
SERIAL INTERFACE BOX
710
ROOM TEMPERATURE SENSOR
712
HUMIDITY SENSOR
714
CARBON MONOXIDE SENSOR
716
SMOKE SENSOR
711
BAROMETRIC PRESSURE SENSOR
(BIOSENSORS)
(ENVIRONMENTAL SENSORS)

FIG. 7

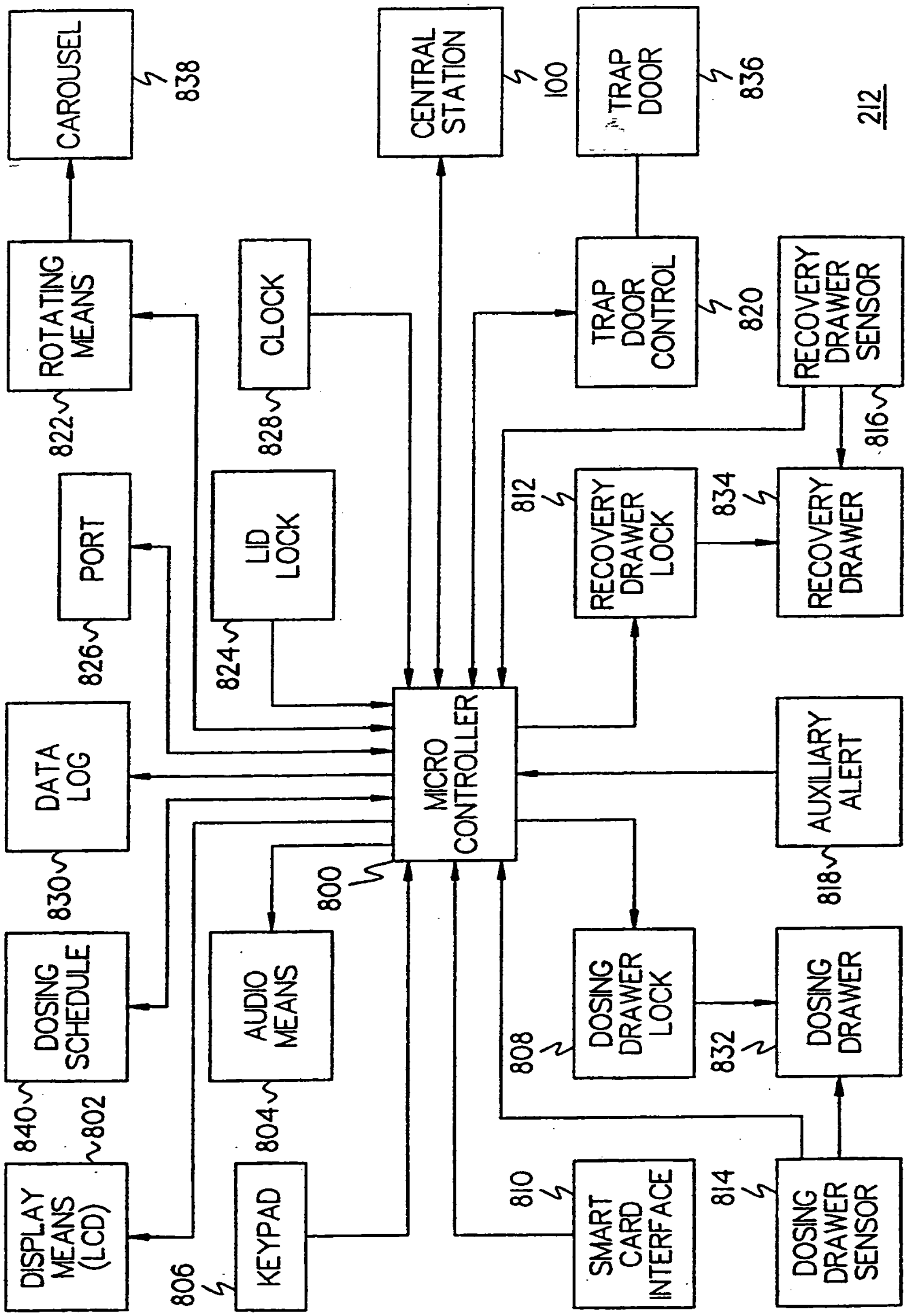

CAROUSEL
838
CENTRAL STATION
100
TRAP DOOR
836
212
ROTATING MEANS
822
CLOCK
828
TRAP DOOR CONTROL
820
RECOVERY DRAWER SENSOR
816
PORT
826
LID LOCK
824
RECOVERY DRAWER LOCK
812
834
RECOVERY DRAWER
DATA LOG
830
MICRO CONTROLLER
800
AUXILIARY ALERT
818
DOSING SCHEDULE
840
AUDIO MEANS
804
DOSING DRAWER LOCK
808
832
DOSING DRAWER
DISPLAY MEANS (LCD)
802
KEYPAD
806
SMART CARD INTERFACE
810
DOSING DRAWER SENSOR
814

FIG. 8